

CLAIMS

Having thus described our invention in detail what we claim as new and desire to secure by the Letters Patent is:

1 1. A method of substantially reducing the number of tile or divot defects that are present
2 in a silicon-on-insulator (SOI) substrate, said method comprising the steps of:

3
4 (a) implanting oxygen ions into a surface of a Si-containing substrate, said implanted
5 oxygen ions having a concentration sufficient to form a buried oxide region during a
6 subsequent annealing step; and

7
8 (b) annealing said substrate containing said implanted oxygen ions under conditions
9 wherein said implanted oxygen ions form said buried oxide region which electrically
10 isolates a superficial Si-containing layer from a bottom Si-containing layer, said
11 superficial Si-containing layer having a top surface which contains a reduced number of
12 tile or divot defects so as to allow optical detection of any other defect that has a lower
13 density than the tile or divot defect.

1 2. The method of Claim 1 wherein step (a) comprises a single oxygen base implant or a
2 base oxygen implant followed by a second oxygen implant, said second oxygen implant
3 is carried out at a temperature lower than the base oxygen implant.

1 3. The method of Claim 2 wherein said second oxygen implant step is carried out using
2 an oxygen dose of from about $1\text{E}14$ to about $1\text{E}16\text{ cm}^{-2}$ and at an energy of about 40
3 keV or greater.

1 4. The method of Claim 3 wherein said second oxygen implant step is carried out using
2 an oxygen dose of from about $1\text{E}15$ to about $4\text{E}15\text{ cm}^{-2}$ and at an energy of from about
3 120 to about 450 keV.

1 5. The method of Claim 2 wherein said second oxygen implant step is carried out at a
2 temperature of from about 4K to about 200°C at a beam current density of from about
3 0.05 to about 10 mA cm⁻².

1 6. The method of Claim 5 wherein said second oxygen implant step is carried out at a
2 temperature of from about 25° to about 100°C at a beam current density of from about
3 0.5 to about 5.0 mA cm⁻².

1 7. The method of Claim 2 wherein said base oxygen implant comprises a high-dose
2 oxygen implant which is carried out using an oxygen dose of about 4E17 cm⁻² or greater.

1 8. The method of Claim 7 wherein said high-dose oxygen implant is performed using an
2 oxygen dose of from about 4E17 to about 4E18 cm⁻².

1 9. The method of Claim 7 wherein said high-dose oxygen implant is carried out at an
2 energy of from about 10 to about 1000 keV.

1 10. The method of Claim 9 wherein said high-dose oxygen implant is carried out at an
2 energy of from about 120 to about 210 keV.

1 11. The method of Claim 7 wherein said high-dose oxygen implant is carried out at a
2 temperature of from about 200° to about 800°C at a beam current density of from about
3 0.05 to about 500 mA cm⁻².

1 12. The method of Claim 11 wherein said high-dose oxygen implant is carried out at a
2 temperature of from about 200° to about 600°C at a beam current density of from about
3 4 to about 8 mA cm⁻².

1 13. The method of Claim 2 wherein said base oxygen implant comprises a high-energy,
2 high-dose oxygen implant which is carried out using an oxygen ion dose of about $4E17$
3 cm^{-2} or greater and at an energy of about 60 keV or greater.

1 14. The method of Claim 13 wherein said high-energy, high-dose oxygen implant is
2 carried out using an oxygen ion dose of from about $5E17$ to about $7E17 \text{ cm}^{-2}$ and at an
3 energy of from about 200 to about 500 keV.

1 15. The method of Claim 13 wherein said high-energy, high-dose oxygen implant is
2 performed at a temperature of from about 100° to about 800°C at a beam current density
3 of from about 0.05 to about 500 mA cm^{-2} .

1 16. The method of Claim 15 wherein said high-energy, high-dose oxygen implant is
2 performed at a temperature of from about 300° to about 700°C .

1 17. The method of Claim 2 wherein said base oxygen implant comprises a low-dose
2 oxygen implant which is carried out using an oxygen dose of about $4E17 \text{ cm}^{-2}$ or less.

1 18. The method of Claim 17 wherein said low-dose oxygen implant is performed using
2 an oxygen dose of from about $1E17$ to about $3.9E17 \text{ cm}^{-2}$.

1 19. The method of Claim 17 wherein said low-dose oxygen implant is carried out at an
2 energy of from about 20 to about 10000 keV.

1 20. The method of Claim 19 wherein said low-dose oxygen implant is carried out at an
2 energy of from about 100 to about 210 keV.

1 21. The method of Claim 17 wherein said low-dose oxygen implant is carried out at a
2 temperature of from about 100° to about 800°C .

1 22. The method of Claim 21 wherein said low-dose oxygen implant is carried out at a
2 temperature of from about 200° to about 650°C at a beam current density of from about
3 0.05 to about 500 mA cm⁻².

1 23. The method of Claim 1 wherein said annealing step is carried out in an ambient gas
2 that comprises from about 0 to about 90% oxygen and from about 10 to about 100% of
3 at least one high-surface mobility gas that hinders oxide growth, said high-mobility gas
4 is selected from the group consisting of He, N₂, Kr, H₂ and mixtures thereof.

1 24. The method of Claim 23 wherein said high-surface mobility gases is N₂.

1 25. The method of Claim 23 wherein said high-surface mobility gas comprises 100%
2 N₂.

1 26. The method of Claim 23 wherein said high-surface mobility gas is admixed with Ar.

1 27. The method of Claim 23 wherein said annealing step is carried out at a temperature
2 of from about 1250°C or greater for a time period of from about 1 to about 100 hours.

1 28. The method of Claim 27 wherein said annealing step is carried out at a temperature
2 of from about 1300° to about 1350°C for a time period of from about 2 to about 24
3 hours.

1 29. The method of Claim 23 wherein said annealing step includes a ramp and soak-
2 heating regime.

1 30. The method of Claim 1 wherein said annealing step comprises the steps of: partially
2 annealing the Si-containing substrate containing the implanted oxygen ions in oxygen so
3 as to form a surface layer of oxygen on the Si-containing and to partially form said BOX

4 region; stripping the surface layer of oxygen; and continuing the annealing to complete
5 formation of said BOX region.

1 31. The method of Claim 30 wherein said partially annealing is carried out in an
2 ambient that comprises from about 1 to about 100% oxygen and from about 0 to about
3 99% inert gas.

1 32. The method of Claim 31 wherein said inert gas comprises He, Ar, Kr, N₂ or
2 mixtures thereof.

1 33. The method of Claim 31 wherein said gas comprises N₂ or a mixture of N₂ and Ar.

1 34. The method of Claim 30 wherein said partial annealing is performed at a
2 temperature of from about 1250° to about 1400°C for a time period of from about 1 to
3 about 100 hours.

1 35. The method of Claim 34 wherein said partial annealing is performed at a
2 temperature of from about 1320° to about 1350°C for a time period of from about 2 to
3 about 20 hours.

1 36. The method of Claim 30 wherein said surface layer of oxygen is removed utilizing a
2 wet etch process that includes an etchant that has a high-selectivity for removing oxide
3 compared with Si.

1 37. The method of Claim 30 wherein second anneal is performed at a temperature of
2 from about 1250° to about 1400°C for a time period of from about 1 to about 100 hours.

1 38. The method of Claim 37 wherein said second anneal is performed at a temperature
2 of from about 1320° to about 1350°C for a time period of from about 2 to about 20
3 hours.

1 39. The method of Claim 30 wherein said second annealing is performed in an ambient
2 gas that comprises from about 0 to about 90% oxygen and from about 10 to about 100%
3 of at least one high-surface mobility gas that hinders oxide growth, said high-mobility
4 gas is selected from the group consisting of He, N₂, Kr, H₂ and mixtures thereof.

1 40. The method of Claim 1 further comprising applying a patterned resist to the surface
2 of the SOI wafer prior to oxygen implantation.

1 41. A silicon-on-insulator (SOI) substrate comprising:
2
3 a buried oxide region that is sandwiched between a superficial Si -containing layer and a
4 bottom Si-containing layer, said superficial Si-containing layer having a top surface
5 which contains a reduced number of tile or divot defects so as to allow optical detection
6 of any other defect that has a lower density than the tile or divot defect.

1 42. The SOI substrate of Claim 41 wherein said buried oxide region has a uniform
2 interface with said superficial Si-containing layer.

1 43. The SOI substrate of Claim 41 wherein said buried oxide region has an undulating
2 defect-containing interface with said superficial Si-containing layer.

1 44. The SOI substrate of Claim 41 wherein said superficial Si-containing layer is
2 smooth and has a glass-like appearance.

1 45. The SOI substrate of Claim 41 wherein said buried oxide region is present
2 continuously through the substrate.

1 46. The SOI substrate of Claim 41 wherein said substrate comprises discrete and
2 isolated buried oxide regions.

